XI. *Some Remarks on the Physiology of the Egg, communicated in a Letter from John Ayrton Paris, M.B. to William George Maton, M.D. V.P.L.S. &c. &c.*

*Read April 4th*, 1809.

Dear Sir,

The extensive range which the *Ovipari* form in the scale of animated existence renders the physiology of the egg a subject of extraordinary interest and importance to the disciple of Linnæus: I am therefore induced to hope that the communication of any new facts relative to its organization and development will be received by you as an acceptable tribute to the cause of natural history.

The *ova*, or germs of oviparous animals admit of an evident division into two orders. I. The Perfect, and II. the Imperfect. The former are deposited by the *Aves*, *Serpentes*, and by most *Oviparous Quadrupeds*, and are completely formed *in utero*; whilst the latter, produced by some of the *Testacea*, *Amphibia*, and by most *Pisces*, acquire additions after their exclusion. The observations contained in this memoir relate more particularly to the class *Aves*, the history of whose *ova* comprehends whatever is interesting or important in the germs of inferior animals. The egg, when completed and deposited, consists of the following parts:—

1. *Vitellus* or *yolk*, with its *capsule* and *cicatricula*; 2. The two *Albumina*

*Albumina*, with their proper membranes; 3. The *Chalazæ*; 4. The *Folliculus aëris*; 5. The *Common Membranes*; 6. The *Exterior Involucrum*, or *Shell*.

The necessity of any description of these parts is superseded by the minute and valuable details which are to be found in the works of Fabricius ab Aquapendente, Harvey, Malpighi, and of many modern and enlightened physiologists; I shall confine myself, therefore, to what I consider exclusively original.

The principal use of the albuminous portion of the egg is doubtless to afford materials for the growth, and nourishment for the support, of the ovular embryon: such however does not appear to be the *only* purpose for which it is designed. No where does Nature display more anxiety for the preservation of her offspring, or more wisdom to obtain her objects, than in her provisions to ensure an equable temperature to the *fœtus in ovo*; a condition which is so essential to the evolution of the animal, that the smallest deviation overthrows the nice balance between the different actions that are to mature it, and produces fatal effects. The *albumen* then I consider as a great defence against such an evil. The *chalaza*, by retaining the *cicatricula* at the source of heat, obviates the mischief that would accrue from constant change of position; but the *albumen*, being a most feeble conductor of caloric, retards the escape of heat, prevents any sudden transition of temperature, and thus averts the fatal chills which the occasional migrations of the parent might induce. As an illustration of the use and importance of such a structure, I may observe, that those fish which retain their vitality a considerable time after their removal from the water, as eels and tench, have the power of secreting a slimy and viscid fluid, with which they envelop their bodies. Is it not extremely probable that this matter, by acting like the albumen of the egg,

and

and preventing evaporation from the surface of the animal, and the consequent change of temperature, may be the principal cause of this tenacity of life?

It must however be remarked, that deviations of temperature are injurious and fatal in proportion only to the degree of vital energy which the ovular embryon possesses: hence germs of inferior vitality not only suffer the vicissitudes of heat and cold with impunity, but are developed by a less defined temperature. We therefore perceive, as we descend the scale of oviparous beings, that those peculiar provisions which the eggs of perfect animals possess, for the regulation of their temperature, cease to be essential, and therefore disappear.

The part of the egg to which I next beg to direct your attention is the *folliculus aëris*, or air-bag, placed at its obtuse extremity; the nature of this follicle excited in me considerable interest, as I found that it had not been so fully investigated as its importance seemed to demand.

The external shell, and the internal membrane by which it is lined, constitute the *parietes* of the cavity, whose extent in the recent egg scarcely exceeds in size the eye of a small bird: by incubation, however, it is extended to a considerable magnitude. That its most essential use is to oxygenate the blood of the chick, in my opinion there can be no doubt: but to establish completely the truth of such a theory, it is necessary to discover the nature of the air by which it is inflated, and which has hitherto remained unexamined. We are informed by Buffon, that it is a product of the fermentation which the different parts of the egg undergo. If the Count's conjecture be established, it must be non-respirable, and therefore cannot discharge the office which such a theory would assign to it. To determine this matter, and to discover also whether the process of incubation produces any change

change in its chemical constitution, I instituted the following experiments; viz.

EXPERIMENT 1.

Twenty-one hen's eggs newly laid, when punctured at their obtuse extremity, yielded only 1 cubical inch of gas, which, when received in a jar, and subjected to the eudiometric test of Dr. Priestley, I found to be pure atmospherical air.

EXPERIMENT 2.

Two eggs, after 20 days' incubation, were opened under the surface of water, from which 1 cubical inch of gas was collected: this I also discovered to be atmospherical air, contaminated however with a small portion of carbonic acid, which I suspect to be derived from the venous blood of the chick, and which seems to establish another most beautiful analogy between this mode of oxygenation, and respiration after birth.

From these results the following corollaries may be drawn: *viz.*

1. The *folliculus aëris* before incubation contains atmospherical air.
2. No other chemical change takes place in the constitution of the air, than a small inquination with carbonic acid.
3. It gains by incubation an increase of volume, which takes place nearly in the ratio of 10 to 1.

I must here remark, that its extent does not increase equally in equal successive portions of time, but observes a rate of progression, which is accelerated as the latter stages of incubation advance: it seems, however, to arrive at its *maximum* of dilatation a few days previous to the exclusion of the animal.

In the eggs of inferior animals, the embryon does not appear to be oxygenated by any distinct apparatus, but, like the animal which

which it is hereafter to become, receives air through the medium of *spiracula*, dispersed over the exterior *involucrum*. The description of the *folliculus aëris* just delivered is taken from that in the egg of our common hen. The same apparatus exists in the eggs of all birds, and contains a similar air: its capacity, however, does not seem to vary either with the size of the egg, or of the bird to which it belongs; but I think I have discovered a beautiful law by which its extent is modified.

I have uniformly found, as far as my contracted inquiries have led me, that the *folliculus aëris* is of greater magnitude in the eggs of those birds which place their nests on the ground, and whose young are hatched fledged, and capable of exerting their muscles as soon as they burst from their shell, than in the eggs of those whose nests are generally built on trees, and whose progeny are born blind and forlorn. Thus the *folliculi* in the eggs of fowls, partridges, and moor-hens are of considerable extent, whilst those in the eggs of crows, sparrows, and doves are extremely contracted. The chick, therefore, of fowls and partridges has a more perfect plumage, and a greater aptitude to locomotion, than the callow nestlings of doves and sparrows. Such an instance of the agency of oxygenation in the promotion and increase of muscular power is not solitary in physiology; for the history of ruminating animals will furnish us with a parallel example. "Their cotyledons," observes the author of *Zoonomia*, "seem to be designed for the purpose of expanding a greater surface for the termination of the *placental* vessels, in order to receive oxygenation from the *uterine* ones: thus the progeny of this class of animals are more completely formed before their nativity than that of the carnivorous classes. Calves therefore and lambs can walk about in a few minutes after their birth; while kittens and puppies remain many days without opening their

their eyes." If any further testimony be necessary to show that the augmentation of muscular energy is the result of a nice combination of oxygen with the animal organs, many interesting facts might be adduced in confirmation of its truth. We generally find the strength of an animal proportionate to the extent of its chest: hence an attention to the "*animosum pectus*" has been attended with the improvement of our breed of cattle; and it is in consequence of a great extent of pneumatic receptacle that birds are enabled to bear the prodigious muscular exertion of flight. Is it not probable, too, that the repeated suspirations of the fatigued are instinctive exertions to procure a greater proportion of oxygen, by which their muscular energy may be revived? I must not quit the subject of this follicle, without noticing a very curious fact well known to every one employed in the concerns of a farm-yard,—that, if the obtuse extremity of an egg be perforated with the point of the smallest needle, (a stratagem which malice not unfrequently suggests,) its generating process is arrested, and it perishes like the *subventaneous* egg. Hence Sir Busick Harwood was led to suspect that the elastic fluid contained in the air-bag was oxygen, and I was induced to examine its nature. Can this curious problem be solved, by supposing that the constant ingress of fresh air is too highly exciting? A parallel example may be adduced from the vegetable kingdom in support of such an opinion. The young and tender plant, before it puts forth its roots, is often destroyed by having too free a communication with the atmosphere, by which its powers are exhausted: it is to obviate such an effect, that the horticulturist, taught only by experience, covers it with a glass, by which he limits the extent of its atmosphere, and consequently decreases its respiration, transpiration, and the inordinate actions which would prove fatal to it.

I shall close this paper with a few observations on the formation of the exterior *involucrum*, or shell, by which this microcosm is defended from external violence. We here detect a single operation, at once answering two of the wisest and most important purposes of the animal: it at once averts destruction from the individual, and contributes essentially to the preservation of its species; for, whilst it removes the calcareous matter, which, if allowed to accumulate, must render the bird incapable of flight, and defeat the best purposes of its existence, it furnishes the germ of the future animal with a strong and convenient defence. The eggs of birds are, however, sometimes destitute of this provision, which I think may arise from the secretion of calcareous matter not keeping pace with the exuberant production of the fluids of the egg. Hence we perceive this imperfection oftener occurring in strong birds, and in the months of harvest, when their food is more luxuriant and abundant. The experiments of Vauquelin, which prove that the quantity of calcareous matter voided by birds exceeds that taken in, suggested to Fordyce, that birds must require calcareous matter during their laying, and that, if the animal be deprived of it, the shell is never formed. Such a theory, however, is not only derogatory to the wisdom of nature, but illegally deduced from the experiments themselves. Are we to expect, from our imperfect notions of elementary bodies, to explain the origin of every substance found in the animal œconomy, or the series of changes which it undergoes? Nature has her own laboratory, and is capable, without any foreign aid, of preparing the ingredients necessary for her productions. That a deficiency of calcareous matter in the system is the cause of the absence of the shell, no one will deny; but that this depends on some internal state, and not on the privation of lime, may be shown by the following curious circumstance.

A hen,

A hen, which I kept for some experiments, had its leg broken in two parts. The fracture was carefully bandaged; three days subsequent to which, several eggs destitute of shells were found on the premises. The hen had deposited no perfect eggs, nor were there any other birds from which these yolks could have proceeded: I therefore conjectured that all the *calcareous matter* designed for the formation of the shell had been employed in the regeneration of the bone. We find a similar law existing in the human species. The reunion of a bone fractured during a woman's pregnancy is often delayed until her delivery; and it is well known, that, if the horns of a deer be broken at the rutting season, it is incapable of procreating its species.—I remain, dear Sir, with great esteem,

Yours faithfully,

JOHN AYRTON PARIS.

Westminster,
November 30, 1808.